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The Mexican oil fields

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THE MEXICAN OIL FIELDS

by

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TABLE OF CONTENTS.

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INTRODUCTION.

Owing to the large area involved in this paper it is proposed to give only briefly the history, geology and development of the oil industry in Mexico, as well as to discuss in a general way the present oil legislation which has brought so much comment in the papers and has raised so much diplomatic trouble between the Mexican and United States Governments. This discussion is therefore of a brief nature and only the most culminant features and details of the subject in mind are here treated.

The information and data here given were accumulated during personal examination of the oil fields from Matamoros and Reynosa in the north to Teziutlan in the State of Puebla in the south; also from a thorough study of the records and reports to date kept by some of the largest companies operating in Mexico.

LOCATION.

The region under discussion is a narrow belt of what is known as the Gulf Coastal Plain of Mexico, and comprises the strip of land beginning just south of the Rio Grande and extending as far south as the State of Puebla, near Teziutlan. Here the Sierra Madre closes

the coastal plain at Dos Atlixcos which constitute the last spurs of the High Siérras extending into the sea. To the west, the area here treated, is bounded by the cordilleras of the Sierra Madre Oriental.

The middle portion of the region is economically important because of the enormous quantity of petroleum that has been developed here during recent years, reaching the vast total of 90,000,000 barrels during the year 1919. The largest part of this output has been produced by a comparatively small number of wells and from an area not over twenty-five miles long by less than two miles in width.

The main port of entrance of supplies for the oil fields is Tampico, which is located about three miles above the mouth of the Panuco River. thus having excellent wharving and loading facilities. Tampico is also reached from the interior by the National Railways of Mexico. The petroliferous region itself lies about sixty miles south of Tampico and about thirty miles inland from the coast, and is reached by wagon roads and through the Laguna de Tamiagua which greatly facilitates transportation as coast sailing is extremely dangerous during the winter months on account of the strong northers blowing over the coast during this season. Numerous esturaries running from the lagoon inland

also facilitates transportation. Several of the companies have also built narrow guage railroads from the oil fields to the lagoon. From the wells, which are all of the gusher type, pipe lines have been built to Tampico and to the coast where the oil is loaded in to tank steamers by means of sea lines.

HISTORY.

The occurrence of crude oil in Mexico was mentioned as early as 1635 by Friar Sahagun, when it was known by the Indian name "chapopote". This name for crude oil has subsisted in Mexico to the present time. Chapopote was gathered from natural seepages and used by the Indians for certain religious and medicinal purposes. In places it was used as a building cement.

In 1865 the first commercial attempt was made to exploit oil and gas, and according to records of the department of Industry Commerce and Labor, Senor Lopez was this year granted permission to exploit petroliferous deposits in the State of Tamaulipas. Other permissions were granted but they were limited to surface seepages. In 1868 a Mexico City Company drilled a well 125 feet deep in the Furbero district, southwest of Tuxpam in the State of Veracruz, and a little oil was refined there. In 1873 residents of Tampico

observed seepages along the Tamesi River and some asphalt was mined in the Tempoal Valley. No drilling was attempted. In 1883 several wells were drilled at Potrero del Llano by a Boston Company, one of which flowed from a depth of 400 feet. Between this year and 1900 several wells were drilled in the State of Veracruz, some of them to a depth of 1500 feet, but without success.

In 1900 Doheny and Canfield of California brought in their first well at Ebano, about 45 miles west of Tampico. This company had quite some success in securing a big production of heavy grade, asphalt base oil. Some of the wells they drilled twenty years ago are still flowing oil, and in some instances with very little decline from the initial production. This company later acquired lands in the State of Veracruz south of the port of Tampico, and were the first to secure a large daily production of crude petroleum.

In 1904, The Oil Fields of Mexico Ltd. (Pearson Interests) brought in their first successful well at Fubero. The great importance of the Mexican fields was not fully recognized until 1908 when the Eagle Oil Company (Lord Cowdray Interests) drilled a well at San Geronimo, about 50 miles south of Tampico, known as

the famous "Dos Bocas Gusher". This well had an estimated flow of 90,000 barrels per day, but due to unfortunate circumstances connected with the "drilling in", caught fire and was a total loss. It is estimated that probably one hundred and fifty million barrels of crude petroleum spouting from this hole in the ground with enormous pressure behind it was consumed by fire or lost by waste. This well was the sensation of the oil industry and was the means of stimulating interest in the further development of the enormously rich oil fields adjoining. A large number of American oil companies or individuals commenced leasing tracts of land in this region and the work has gone on to such an extent that to-day there is approximately one billion dollars of American capital invested in these fields the actual value of which is almost beyond estimation.

After the Dos Bocas fire, an American corporation, The Mexican Petroleum Company, (Doheny Interests) commenced active drilling operations on lands located approximately ten miles to the south of the location where the fire occurred. They had great success, having drilled in several gushers, among which is the famous Casiano No. 7, which was completed in the Fall of 1910 and which up to the Spring of 1920 produced daily 23,000 barrels of oil.

In 1910 the Cowdray interests drilled at "Potrero del Llano" 25 miles south of Casiano and brought in No. 4 well, which on actual test, produced more than 100,000 barrels daily.

Between 1910 and the present time many other companies have brought in large producers and, in spite of the fact that the Mexican revolution was in force for many years, building and drilling operations during these troublesome times were continued unabated. Especially is this true of the past year which has shown a greater increase in production and progress of development than any previous year. This may be taken as an indication that the whole world looks to Mexico for their future supply of petroleum.

PHYSIOGRAPHY.

Topographically the area is controlled by the Gulf Coastal Plain sloping gently gulfward. This plain has an average width of 65 miles. Along the western border there are the ranges of the Sierra Madre caused by the intense folding and faulting of the Cretaceous rocks and which constitute the eastern flanks of the Mexican plateau. The topography to the east of the Sierras is broken by a series of hills and peaks of

intrusives. South of the Panuco river these interruptions are more numerous than to the north, being especially prominent at Chicontepec, Tontontepec and Tantima, where they separate the drainage of the Panuco from that of the Tuxpam River. Other minor basins are formed by series of hills which form the valleys drained by the Cazones, the Tecolutla and the Nautla Rivers, between Tuxpam and Teziutlan. Streams of minor importance such as the Tancochin, La Laja and the Cucharas Rivers drain the smaller basins found between Tuxpam and Tampico. To the north of Tampico the only river of importance is the Soto La Marina River.

The impervious nature of the surface rocks composed of marls, shales and clays found in the area near Tampico has given rise to numerous lagoons and marshes. About thirty miles south and east of Tampico the impervious rocks disappear under limestones and sands which allow an easier drainage and form a series of ridges and valleys of more or less regular relief. South of the Panuco River rainfall is heavy, especially during the summer months. Much of it is absorbed by the tropical growth covering the area, the run off being comparatively light. North of the Panuco the rainfall is lighter and the region here is semi-arid, something like a transition between the arid plains of south-

western Texas and the fertile tropical lands of northern Veracruz.

GEOLOGY.

General Considerations.- The decline to the gulf, which constitutes the area under consideration extends from the eastern escarpments of the Sierra Madre Oriental and reaches the coast forming a gentle, dipping monocline, averaging 30 to 40 feet to the mile. This monocline is covered mostly with Tertiary formation with here and there deposits of Quaternary age and intrusives of basalt in the form of plugs and dikes which modify the general geologic features of the area. The western part of this monocline is very much folded and faulted, thus giving rise to the eastern flanks of the Sierra Madre Oriental which are composed of Cretaceous rocks. Much confusion has arisen due to the fact that correlations are very difficult to make because the shale members, covering a large part of the area are unfossiliferous and their lithologic characteristicts are so similar that identification is exceedingly difficult. By position, some of these shales in the northern part have been identified as belonging to the Cretaceous,

while apparently the same shales have been found in the south to be of Eocene and even of Oligocene age.

No rocks older than the Cretaceous outcrop anywhere in the area and even the core of the Mexican plateau is formed by rocks of this age. The oldest formation yet reached by the drill, namely the lower Tamasopa limestone also belongs to the upper Cretaceous as fully proved by Rudistes blown out of the gushing wells.

Many geologists differ as to the names of the different formations of this area; however, when the characteristics of each formation are compared as well as their location, these beds although different in name can be identified as the same. The following table shows the stratigraphy of the Mexican Gulf Coastal Plain. This classification was used altogether by the writer and was made up from the different sections made by Mexican and American geologists together with modifications made from personal observations. If compared with other geologic tables it will be fouhd that it differs only in detail but in the main part it is very much the same. The formations are named after the places where the best sections are exposed, and the identification of most of the fossils was done with the help of paleontologists employed by the largest companies.

STRATIGRAPHY.

PLIOCENE	Reynosa Beds.	Thick conglomerates. White brecdias Limestone oyster beds.	Non Fassiliferous
		Unconformity	
OLIGOCENE.	Tuxpan Beds Entire series 23 KM from the coast. Topila	Flags of yellow sd. st. thin bedded.	Small Glebular Orbitoidea
		Massive cavernous yellow sd/st	Small Globular Orbitoidea Pecten gatunensis
		Same sd. st. which contains black pebbles of all sizes.	Arca sp. Mactra sp. Gastropods of various types: Voluta sp. Turritella sp. Conus sp. Var. Corals.
	Tuxpan Beds. Laid down in shallow water 25 KM from coast Topila 60'	Flags of yellow sd. st. thin bedded always level undisturbed by folding.	Non fossiliferous
		Marls, clay conglomerate layers of black pebbles interbedded.	Small Globular Orb. Big Corals. Turritella sp.

TERTIARY.

TERTIARY.	OLIGOCENE	Tuxpan Beds. reef facies 15 KM from the coast. San Jose 400'	White coral limestone with big silicified corals.	
			Massive white oolitic limestone	Corals of various types Pecten gatunensis Arca sp.
			Calcareous sd. st. very coarse and loose black pebbles.	Corbis sp. Mactra sp. Turritella sp. Crustaceans
			unconformity	
		San Rafael Beds.	Clays with sandy layers interbedded. Nearer to the coast sandy limestone.	Orbitoides ephippium Small Globular Orb. Meterostegina Turritella sp. Dentalium sp Pecten gatunensis Pecten ox gonum Clypeaster Concavus Schizaster scherzeri
			Massive limestone with black pebbles	Orb. ephippium Orb. papyracea Small Globular Orb.

TERTIARY.

OLIGOCENE		Great thickness of yellow limestones.	Nummulites radiata Clypeaster concavus Macropneustes sp. Corals.
		Unconformity	
	Meson Beds	Massive yellow lime stone. Very local.	Orb. papyracea Corals.
		Unconformity	
	Meson Beds	Thick series of massive s.s. called Tacuba ss. in the Topila region. Only found on top of the highest uplifts.	Schisaster sp. Small Orbitoides.
EOCENE. (Upper)	Alazan Beds	Great thickness of very soft greenish marls and clays with thin sd. st. layers. Gypsum, pyrite. Always sandy.	Operculina at the top Schisaster sp. Sporadeous small fossils; Pecten sp. Gasteropods; prints of leafs.
	Chicontepec Beds.	Radidly alternating sandy limestone and shales, calcareous sd. st. layers massive sd. st.	Orthophragmina sp. Nummulites sp. Turritella sp. Cardium sp.
		Unconformity	

C R E T A C E O U S.	UPPER	Papagallos Beds	Great thickness of soft impalpable greenish gray clay and shales. Shale marker in well-logs 750' from the top.	No microspopic fossils. Globigerina. Textularia etc.
		----------	Unconformity----------	
		San Felipe Beds.	Alternating series of shells, massive white limestone, sandstone and marl, shales, grading gradually into the Papagallos by drilling experience the top is based upon the first shell.	No fossils.
	MIDDLE	Tamasopo	Massive brown and blue limestone.	Rudistes in upper part

CRETACEOUS BEDS.

Geologists of the Mexican Geological Institute divide the Cretaceous into three sections but for our purpose we will only refer to the upper Cretaceous as the top of this formation is the lowest member reached by the drill and the oldest one of any economical importance. Furthermore, the lowest part of the upper Cretaceous is below the Tamasopo formation shown in the table here given and it is at the top of the Tamasopo where the oil is believed to be stored. The lowest formations are of no economical importance as in actual practice the geologist only wishes to determine the depth at which the bearing "sand", namely the Tamasopo is found.

The Tamasopo.- The Tamasopo limestone or lowest member of our series, is rather fine grained, and creamy to light gray in color. The lowest part is massive while the top is very fossiliferous. In the whole region here described the Tamasopo limestone is the principal oil producing formation with the exception of the Alamo and Furbero fields where the bore has failed to reach the lime and production has been obtained from the upper members.

The Tamasopo and the formations just below

outcrop along almost the entire east ernescarpment of the Sierra Madre from San Juan in Tamulipas to Orizaba in Veracruz. The writer identified it at Victoria, State of Tamulipas, Las Palmas, San Luis Potosi, Xilitla in Hidalgo, at Acatepec and Almanza in Puebla, and east of Huachinango in western Veracruz.

The thickness of the Tamasopo is approximately over 3,000 feet. The upper part of this formation is looked upon by all geologists as the chief pay formation; it is very porous and it contains great solution caverns which constitute ideal reservoirs for the accumulation of oil in large quantities. such as characterize all Mexican wells. However, there is slight evidence of petroleum in the lower formations, and altho some geologists assert to have found particles of petroleum in the dolomitized limestone of the formations below the Tamasopo, there is no evidence to show that the oil is indigenous to the limestone. It is possible, however, that this highly porous and shattered limestone may have played an important part in the accumulation of oil, especially where the member has been fissured and broken due to igneous activity. An evidence in this respect is the occurrence of all gushers in or near areas intensely fractured by igneous intrusions such as plugs, dikes and sills.

San Felipe Beds.- Overlying the Tamasopo limestone there is an alternating series of shells, massive white limestone and many shales gradually grading into the Papagallos formation above. By drilling experience the top is considered to be the first shell encountered by the bit. A good section of this formation is exposed at San Felipe on the San Luis Potosi and Tampico railroad.

The limestone members of the San Felipe are not as compact as the limestones below, and the alternating beds make an excellent oil reservoir which is capped by the thick layers of impervious shales of the upper formations. The San Felipe wherever exposed has a strong oily odor and there is no doubt that it constitutes one of the most important sources of oil in the Mexican fields, especially where fractured and folded by igneous intrusions.

The thickness of the San Felipe varies from 300 feet up to 800 feet and cannot be actually determined because it gradually grades into the upper formation or Papagallos. Some geologists consider the San Felipe as a transition series between the marls and clays called by them Mendez shales and the Tamasopo limestone below. Their reason for this belief is that the shale members of the San Felipe increase towards the top, while the limestone members increase toward the

bottom giving place to the massive limestone of the Tamasopo. The San Felipe is unfossiliferous and is distinguished in the field only by its position and lithologic characteristics which are quickly recognized by the eye trained to observe them.

Pappagallos Beds.- Lying unconformably upon the San Felipe there is a series of very fine-grained blue or black limy, clay shales, leaching brown, yellow or white. They carry both selenite and barite and break up into slaty particles. When broken down and fully weathered they form a black clay which when wet makes a very stiff mud. These shales extend all along the Tamaulipas Mountains and can be recognized at Gonzalez, Los Esteros and El Abra down to Aquismon where it most probably was eroded away or is now covered by the Eocene beds of Chicontepec formation. In actual drilling the Papagallos Beds are recognized by its great thickness of soft impalpable greenish grey clay and shale. The shale marker in the well logs is at about 750 feet from the top. They do not have the microscopic fossils such as Globigorina and Textularia. At times the Papagallos is entirely missing while at others its thickness varies greatly which seems to indicate the existence of erosional unconformities between this formation and the formations immediately below and above. The Papagallos beds are usually

found dipping in a different direction and at a steeper angle than the Tertiary beds overlying them. This fact seems to be the evidence of an unconformity between the upper Cretaceous and the Chicontepec beds of the Eocene.

TERTIARY.

Eocene.-

Chicontepec Beds.- This formation consists of rapidly alternating sandy limestone and shales, calcareous sandstone and massive sandstone. The characteristic fossils of the Chicontepec are the Orthophragmina, Orbitoides sp. Nummulites sp. Turritella sp. and Cardium sp. The Chicontepec beds are strongly folded like at Chicontepec where the typical exposure is found, and almost everywhere it shows much stronger dips than the overlying formations. In the whole it seems to have been eroded and folded prior to the deposition of the upper beds of the Eocene called Alazan. The Chicontepec reaches is a thickness of over 2500 feet, as seen at the wells drilled north of the Tempoal Valley where fossils have been found in the drill cuttings by which this formation has been identified.

Alazan Beds.- The uppermost formation of the Eocene in the area here considered consists of the Alazan beds which to all appearances lie unconformably upon

the Chicontepec. They consist of a great thickness of very soft, greenish marl and clay with sandstone layers, gypsum and pyrite. The beds of the Alazan formation are always sandy and are identified by the Oporeulina at the top. They also contain the following fossils: Schisaester sp., Sporadeous, Pecton sp. Gasteropods and prints of leaves. The typical Alazan shales are found on the Buena Vista River, near Alazan; also near Horcones,at Paso Real and at Topila. Some exposures are very fossiliferous. It is everywhere overlain by sandstones and shales of the Oligocene.

Oligocene.-

The Oligocene formation reaches in places a thickness of over 1000 feet and extends over wide areas. This formation is found all along the eastern slope of the Gulf Coast from Conchos River in northern Tamaulipas to Larios and Sanja de Arena near Nautla in southern Veracruz. In some area like near Topila and Papantla it reaches a thickness of over 1000 feet.

The Oligocene deposits consist of sand, sandstones, clays, shales and marls with more or less calcareous matter and limestone, and are very fossiliferous throughout. Based on these fossils the Oligocene has been divided into three members which beginning with the lowest are: the Meson, the San Rafael

and the Tuxpam.

Meson Beds.- This formation consists of a series of massive sandstones the lower of which are hard and compact and go by the name of Tacuba sandstone in the Topila region. This sandstone is only found on top of the highest uplifts and in my personal opinion they constitute part of the Alazan beds washed out and solidified by some diagenetic process due to the uplift above sea-level. The Meson formation lies conformably upon the real Alazan beds and its characteristic fossils are Schisaster sp. and small Orbitoides.

It seems that during the deposition of the lower Meson or Tacuba sandstones the Eocene sediments as well as the lower Meson were elevated, folded and base leveled. It is on these sediments that the upper Meson beds as well as the upper formations of the Oligocene were deposited and which constitute at present the various mountains, hills and valleys of most of the area where erosion has not reached the underlying Eocene.

The upper Meson beds lying unconformable upon the Tacuba or Lower Meson consist of massive yellow limestones which are identified by the Orbitoids papyraceae. This formation is very local and its

characteristic fossils have not been found in any of the upper formations. It has been found unconformably underlying the San Rafael beds.

San Rafael Beds.- A typical section of these beds is found near San Rafael, in the State of Tamaulipas and consists of clays with interbedded sandy layers, while nearer to the coast sandy limestone also are found. One typical characteristic is the existence of pure white concretions in the clays.

The lower beds of the San Rafael consist of massive limestone with black pebbles and a great thickness of massive yellow limestone. These two members, however are very local in their development. The San Rafael is characterized by the Orbitoids epphippim, Numulites radiata, numerous corals and other fossils as given fully in the table. The San Rafael beds extend over large areas attaining in places a thickness of over 200 feet. They are found in the vicinity of Tampico and seem to be unconformable with the Tuxpam formation above.

Tuxpam Beds.- This formation is composed of very fossiliferous clays, shales and sandstones, and lies

almost flat on the beds below. The San Rafael beds, on the contrary show folding which is an evidence of unconformity between the Tuxpam and the San Rafael. The lithologic characteristics of both formations is almost the same, and the only distinction between the two is their position and the fossils found in them. The fossils of the Tuxpam formation are more numerous than those of the San Rafael and such fossils as the Echinoderms are different. Furthermore, the corals in the San Rafael are fewer and smaller.

The Tuxpam beds very from place to place. At Topila, about 25 kilometers from the coast the Tuxpam section is as follows from the top down: First, flags of yellow thin bedded sandstone containing globular small Orbitoids. This is followed by massive cavernous yellow sandstone containing globular small Orbitoids and Pecten gatunensis, which is underlaid by some sandstone with black pebbles of all sizes and containing Turritella, Gastropods and other fossils as shown in the table.

The Tuxpam beds laid down in shallow water are distinct from the deep water beds and consist of flags of yellow thin bedded sandstone and always level and undisturbed by folding. They contain no fossils.

These beds are underlaid by marls, clay conglomerate and interbedded layers of black pebbles, containing globular small Orbitoides, big Corals and Turritella sp.

The Tuxpam beds at San Jose de las Rusias, about 15 kilometers from the coast are different from the Tuxpam beds described above. The following is a section of these beds: First there is a calcareous sandstone very coarse and loose with numerous black pebbles containing Mactra sp., Gerbis sp. and Turritella sp. On top of this sandstone there is an oolitic, white, massive limestone containing Corals of various types and Pecten gatunensis which is followed by white coral limestone with big silicified Corals.

Pliocene.

The Pliocene identified in this area is composed almost entirely of the Reynosa beds, especially in the northern end of the region under consideration. These Reynosa beds consist of thick conglomerates, white breccias, sands, gravels, limestone, and oyster beds with some calcareous clays which in places take the form of caliche. They are of no economical importance whatever.

Igneous Rocks.-

Nearly all the igneous rocks appearing in this region are basaltic dikes, plugs or necks and lava flows. These flows no doubt occurred after the deposition and

folding of the entire series of sediments, as the lava covering is plainly seen to rest upon the sand, conglomerates and calcareous clays of the Oligocene. The relation of the igneous intrusions of this area to oil accumulation has already been discussed in another section of this paper.

STRUCTURE.

Most of the folding and faulting that has taken place in the Mexican Gulf Coastal Plain has no doubt been caused by the stresses which resulted in the formation of the Eastern Sierra Madre Mountains. This folding and faulting necessarily afforded lines of weakness along which the igneous rocks were later intruded and which consist mainly of basalt dikes running in a general way parallel to the strike of the sedimentary formations. In places where two or more of these basaltic dikes intersect, they form a neck or plug which has caused some disturbance in the sedimentaries adjacent to it.

It is of great importance to note the fact that nearly all seepages are found closely related to these igneous intrusives, and the crude oil is usually seeping from the contact of the basalt with the sedimentaries. Furthermore all producing wells are found close to igneous plugs and dikes which seems to indicate that the intrusives have played an important part in the

formations of cavities, crevices, etc. where the oil has accumulated in large quantities. In the Furbero field, for instance, actual drilling has disclosed the fact that the oil accurs directly under igneous sills, the igneous sheets serving as an effective cap-rock.

During the formation of the Sierra Madre Oriental the whole coastal plain was tilted to the east forming a monocline which covers the whole oil region. This east dipping monocline was later modified by local disturbances caused by igneous intrusions and local stresses, the main one of which was that caused by the Tantima and Otontepec igneous masses which upturned the monocline to the northeast.

There are no doubt numerous seepages, faults, folds, dikes etc., occurring in the Mexican fields, but their location is exceedingly difficult to find as the dense tropical growth covering the whole area conceals practically all the evidence which might help the geologist in the tracing of minor structure.

ORIGIN AND OCCURRENCE OF THE OIL.

Most of the oil found in the Mexican fields has been produced by the Cretaceous rocks and it is stored at the contact of the Tamasopo limestone and the San Felipe formation just above, and also within

the pores and large cavities of the upper Tamasopo caused by the shattering action of the igneous intrusions. The great thickness of the impervious shales overlying these oil "sands" have formed an ideal cap-rock which has prevented the escape of the oil.

Practically nothing is known as to the origin of the oil but it can be definitely stated that it does not originate in either the tertiary shales or the cretaceous shales above the Tamasopo as they show no signs or contain no organic matter to account for the formation of oil in such vast quantities as is characteristic of the Mexican fields. Neither do the Cretaceous limestones, on the other hand, show any evidence to prove that the oil is indigenous to the Tamasopo. However it is the only formation where the oil could possibly have originated and it is probable that the Cretaceous limestones furnished the organic matter from which the oil originated. The oil yielded by the Cretaceous migrated towards the upper formations aided by water action, and accumulated in the cavities formed by igneous intrusions as well as in the more favorable zones of the San Felipe. It is also probable that the Cretaceous limestones gave off their oil before they had reached their present state of crystallization or possibly the crystallization was simultaneous with the condensation of the oil.

The Mexican Geologist J. D. Villarello in his paper entitled "Algunas Regiones Petroliferas de Mexico" published by the Mexican Geological Institute states that the oil is probably the product of the decomposition of the marine fauna of the Cretaceous which perished gradually with the oscillation of the region, and concludes that the oil originated from the slow decomposition of their organic matter, citing as an evidence the existence of Cretaceous limestones at Publiche, State of San Luis Potosi, which are impregnated with unaltered petroleum.

THE OIL FIELDS.

The principal oil districts may be grouped from north to south as follows:

The Soto La Marina District.-

This is the northernmost field and it is located in the State of Tamaulipas about fifty miles north of Tampico. There are numerous seepages in this area and several wells were drilled here by the Corona Company, (Royal Dutch Shell); however none of the wells has been productive and the field has lately been abandoned by the company. It is reported that the Marland Oil Company has taken over this property which consists of over two hundred thousand acres of prospective territory, and that

they intend an intense development of the same.

Nearly all the wells have been drilled close to the largest seepages and only showings of oil have been obtained. Sills of considerable thickness have been struck at various depths which at times have rendered drilling operations very difficult. Some of the wells reach a depth of over 4,000 feet but none of them have been drilled to the usual producing "sand" known as Tamasopo limestone, and although the wells have been placed in the lowest parts of the folds the great thickness of the formations above the producing member has so far hindered successful development. Conditions at the surface are very favorable and there is enough evidence to indicate the presence of oil reservoirs somewhere in the lowest formations, such as large oil seepages, anticlinal folds and igneous intrusions which usually accompany productive territory. The eight wells drilled in this area are by no means a test to the field as the seepages extend for a distance of over forty miles. Furthermore it should not be attempted to reach the Tamasopo lime but production should be looked for just above the San Felipe formation, as block faulting which no doubt occurs in this area makes it practically impossible for the bore to reach the Tamasopo. All indications seem to show that

this field is a transition between the Texas field and the Veracruz field and that if production is ever encountered, it will not be of the gusher type but some where between the small production of the Texas well and the large production of the Veracruz gusher.

The Ebano District.-

This district is located about 40 miles west of Tampico and comprises the Ebano, Chijol, La Pez, Santa Margarita and the Laguna wells located along the National Railways of Mexico from San Luis Potosi to Tampico. All these wells are the property of the Mexican Petroleum Company and are the oldest in the region. The oil is heavy and asphaltic in base of about 12 degrees B. Some of the wells are noted for their longevity of production; the La Pez wells, for instance, have been producing since April 1904 an average of 1,200 barrels per day. The Ebano oil is mostly used for fuel by the railroads and is transported entirely in tank cars. The heavy constituents of the oil are used for the manufacture of asphalt.

The Panuco District.-

The most important fields in this district are the Tamboyoche, Isleta, Panuco and Topila fields. The oil ranges from 12 to 13 degrees B. and is all transported in barges down the Panuco River which is navigable

beyond the town of Panuco. On account of the low gravity of the oil transportion through pipelines has not been successful as it requires heating stations which render the process uneconomical. Several large wells have been obtained ranging from 2,000 up to 100,000 barrels per day. The Topila field has been almost entirely exhausted and the whole region has suffered very much by the inflow of salt water. It is likely that intensive prospecting will be carried on as there still remains considerable prospective territory. Geology here, however, plays but a small part as most of the region is marshy and covered by heavy soil, and there is little geological surface evidence to be of any help to the prospector.

One striking feature about the Panuco district is that wells off-setting each other not over 200 feet differ considerably both in production and depth. As a matter of fact producing wells have been drilled within a distance of two hundred feet which differ as much as 400 feet in depth while of two others, the same distance apart one was dry and the other one was a 20,000 barrel well. The only explanation for this irregularity is the existence of block faulting and cementing. However there is no evidence of such at the surface where only shale is exposed over a large area of marshy land.

The Tempoal District.-

This district is located along the Tempoal River Valley about 100 miles southwest of Tampico. It has recently been explored by the Aguila Company, (Cowdray Interests) but their first well which at this writing it is reported to be down to a depth of 3,800 feet and still in the blue shales of the upper Chicontepec formation is a dry hole with no showings of gas or oil.

There are light oil seepages in this district and nearly all the large companies hold acreage for which they have paid exorbitant prices. None of them, however, have started drilling operations as the results obtained by the Aguila Company are by no means encouaging. The paying formations are no doubt beyond the reach of the drill and unless block faulting has occured in this district, it is likly that this field is located in a syncline as the Tamasopo is found nearer to the surface both to the east and west of the area.

The Southern District.-

This district comprises the Tanhuijo, Tepetate, Chinampa, Los Naranjos, Amatlan, Zacamixtle, Alazan, Tierra Amrilla, Cerro Azul, Potrero del Llano and Alamo fields. These fields are the most important as it

is their production that has brought Mexico into prominence as an oil producer.

The southern field oil averages from 19 to 23 degrees B. and it is easily transported through pipelines. In this district are located the greatest flowing wells ever drilled. The first well, The Dos Bocas No. 3 came in on July 4, 1908 but immediately caught fire as the gushing oil spreading over the ground ignited from the fire under the rig boiler which could not be put out in time. The well burned until August 30 when the fire was extinguished during a temporary cessation of the flow. It is estimated that from 60,000 to 75,000 barrels of oil were consumed each day for a period of two months. The cost of extinguishing the fire and capping the well was 3,000,000 dollars. During the height of the fire the flames reached an elevation of 14,000 feet and a width of 75 feet. Newspapers could be read at a distance of 17 miles, headlines at a distance of 33 miles, and ships could see the fire at a distance of 100 miles.

The most productive well ever drilled in this district was the Casiano No. 7 located 20 miles south of the famous Dos Bocas well. This well belongs to the Huasteca Petroleum Company (Doheny Interests) and was brought in on September 11, 1910 and up to 1920

was still making 20,000 barrels of 22 degrees B. oil per day without any water, and ten to twelve million cubic feet of gas. When shut immediately after the flow started it showed a pressure of 600 pounds and commenced to flow out of the ground over an area of two acres at a rate of 4,000 to 5,000 barrels. It was opened so that the pressure was kept at 300 pounds, at which pressure the oil no longer came in through the ground. The total production of this well up to the early part of 1920 when the well was closed on account of an inflow of water, was estimated to be over 70,000,000 barrels of oil which is the largest amount of oil ever recovered from any one well.

All the Chinampa, Tepetate, Los Naranjos and Amatlan wells have been large gushers averaging from 20,000 to 35,000 barrels each. These fields which practically constitute the same pool extending for a distance of about ten miles have produced over fifty five percent of the entire oil output in Mexico. Unfortunately they have lately been invaded by salt water which has compelled the operators to close the wells. Some of the wells are still yielding a little oil by cutting down the production and working the well at high pressures, thus avoiding the emulsifying of the oil with the water.

The third large producing well of this district is the Potrero del Llano well No. 4 of the Aguila Company (Cowdray Interests) situated about twenty-five miles south of Juan Casiano and which yielded for some time at a daily rate of 100,000 barrels. The well was drilled in on December 27, 1910 and before it was controlled over a million barrels of oil escaped into the river. This well gushed an eight inch column of oil to a height of 640 feet. The daily flow increased until the middle of March 1911 when it was estimated to be flowing from 75,000 to 100,000 barrels of 22 degree B. oil per day. In August 1914 this well took fire and burned until the end of the year when it was extinguished during a cessation of the flow. After flowing for a long period it took fire again and this time it burned until May 1919 when the well itself was extinguished by salt water invasion.

Drilling operations have been carried on rapidly, south of Naranjos into Amatlan and Zacamixtle but unfortunately the Zacamixtle wells are short lived and although they have a large initial production it falls down very rapidly. This fact indicates that the large pool which has produced the vast quantities of oil yielded by all these gushers is being exhausted, and as the southern end of the pool is also being

invaded by salt water, the big Mexican gushers soon will be a thing of the past. It is true that there still remain large areas to be prospected, but it will take a long time before new wells of the gusher type will be found, and the oil companies will have to spend vast sums of money, while oil will attain the highest price yet on record.

Other successful, large wells of the gusher type have been drilled at Tierra Amarilla and Cerro Azul, but the former field has also been invaded by water and the latter belonging to the Huasteca Petroleum Company is reported (Feb. 1921) to have shown as much as six percent water.

The Alamo field is located about twelve miles south of Potrero and has produced large quantities of oil, but like the rest of the southern fields it has been invaded by water. The Alamo field differs from the rest in that the oil comes from a higher formation than the Tamasopo limestone which has not been reached by the drill. The Alamo oil is of a higher gravity, namely 23 to 24 degrees Baume.

The Tanhuijo field is fully operated by the Aguila Company. It lies about fifteen miles east of the Naranjos field. Here only small wells of the pumping type have been obtained. Lately, October 1920,

the Tanhuijo field was entirely abandoned by the Aguila Company as it could not be operated on a commercial basis. The oil pay is above the Tamasopo, probably in the San Felipe or Papagallos formations.

The Tuxpam District.-

This district includes all wells south of the Tuxpam River and the Furbero field. Drilling operations did not begin south of the river until the latter part of 1920 and up to this writing none of the wells have been drilled to the Tamasopo limestone. One remarkable fact about this field is that a big gas pay was struck at San Isidro at a depth of 300 feet. It is expected that these wells will be producers as they are inside of the belt of seepages running northeast and southwest. All the wells of the southern field are inside this belt and it is considered as an unfailing territory.

The Furbero field is the southernmost of the developed fields in the Tampico-Tuxpam region. It lies about fifty miles south by east of Potrero del Llano. It was developed by the Oil Fields of Mexico Ltd. but lately has been taken over by the Aguila Company. The Furbero field is of extraordinary interest and importance because it represents a new type of oil deposits in and adjacent to igneous rocks, for the so called

"sand" is either a decomposed gabbro sill or the metamorphosed shale adjacent to it. The oil occurs in commercial quantities in both the igneous rocks and in the sediments. The largest well came in at about 1000 barrels from the under metamorphic zone. It has produced nearly 500,000 barrels and apparently mostly from the igneous rock reservoir. The production is pumped to the Tuxpam bar where it is shipped by means of sea-loading lines. The field is not operated at present.

PRODUCTION.

There are many oil companies operating in Mexico but the bulk of the production is in the hands of a few large financial interests such as the Mexican Petroleum Company Ltd. and subsidiaries, at present the largest producers and most successful operators. The Aguila Oil Company (Pearson Interests) second largest producers. The Corona Oil Company (Royal Dutch Shell) The East Coast Oil Company (Southern Pacific). The Agwi Oil Company (Atlantic Gulf and West Indies). The Mexican Gulf Oil Company (Gulf Refining) and several large companies affiliated with the Standard such as the Penn Mexican, The Transcontinental Petroleum Company, The Island Oil Company etc.

Up to December 1919 there had been drilled in Mexico 1275 wells with a total production of eighty-

seven million barrels. There are 1138 steel tanks, ten refineries and topping plants in full operation and four large refineries under construction. However most of the oil is exported in the crude, just as it comes out of the well. The oil exports in 1920 exceeded 180,000,000 barrels of oil and according to the last reports during the month of January alone, 18,481,136 barrels of oil were shipped from Mexican ports by twenty-one oil companies. These figures put Mexico at the head of the world oil producers.

The bulk of the production, namely that of the southern fields averages 19 to 20 degrees Baume in gravity and the other properties are as follows:

Flash point	95
Viscosity	500 B. O. T.
Sulphur	2.1 percent
Base Sediment	2.2 percent
B.T.U.	19800 per lb.

The oil is dark in color and contains large amounts of hydrogen sulphide and carbon dioxide. The Panuco oil is heavier, averaging 11.5 to 12.5 degrees Baume. Its sulphur contents are also higher. The gas from the wells is very poisonous and has caused the death of many men. South of Topila the gas issuing from the oil contains such amounts of carbon dioxide that it

freezes as it comes out through the casing head, when expansion of the gas takes place. Little of the gas is used for the manufacture of casing-head gasoline as only two small plants have been built at Casiano and Alamo. Owing to its poisonous nature all the rest of the camps burn the gas as it issues from the wells. The amount of gas thus wasted can be estimated when it is considered that each well averages over eight million cubic feet of gas.

Drilling.-

Both the Standard and Rotary drilling methods are employed in the Mexican fields and remarkably good results have been obtained by the use of the Rotary system in the upper formations which are mostly composed of soft shales and marls and having an average thickness of about 1,500 feet. Standard tools are used after the soft formations have been passed.

Transportation.-

The transportation of the oil to the shipping points is controlled by the viscosity of the oil and the distance of the producing well from port.

Oil of light gravity like the southern field oil is successfully pumped through pipe lines from the field to Tampico, Tuxpam and Port Lobos. There are excellent wharfing facilities at Tampico where the tank-steamers can be efficiently loaded from the storage at the companies terminals. The loading of tank-

steamers at Tuxpam and Port Lobos is not so efficient, as the tankers have to anchor a long distance off shore where they are loaded by means of a flexible pipe connected to a submerged line rum from the storage tanks on the coast. Nearly all the large companies have double and even triple lines from the fields to the shipping centers, varying from eight to twelve inches in diameter. The pipe lines of the larger dimensions are more efficient as it has been found out that owing to the viscosity of the oil a twelve inch pipe will do more efficient work than two eight inch lines.

Heavy oil like that of Panuco and Ebano cannot be pumped economically through pipe lines. The former is barged down the Panuco River to Tampico for a distance of about 50 miles, while the latter is shipped in railroad tanks after removing the heavier constituents, which are used for asphalt manufacture at Ebano.

It is plain, therefore that owing to the lack of transportation facilities, wells, other than gushing wells are not commercially profitable in Mexico, and pumping wells like those at San Pedro and Minatitlan are not exploited, even if the gravity of the oil is high (over 45 degrees B.) for the reason that they

are in districts far from seaboard. The same will hold true for the Tempoal District where if they ever discover oil wells, unless they are of the flowing type, they will not be commercially valuable.

LEASING.

Oil land is obtained by the oil operators either through lease or by purchase, but owing to Article 27 of the Constitution of 1917 which declares that ALL THE SUBSOIL RIGHTS ARE VESTED IN THE NATION the oil companies in order to secure their rights over the land they have leased or purchased, must also denounce their properties before the Federal government. But as article 27 is still before Congress, the Mexican Executive has issued a number of decrees prohibiting the lease of subsoil rights from the land owner, and only permitting drilling operation on land denounced from the government. A preferencial right of denouncement is given to the landowner himself. However, as owing to outside pressure and influence it is not known whether article 27 of the new Constitution, will be finally passed by Congress, in order to offset the dispositions issued by the President, the oil companies acquire by written contract with the owner, not specifically the subsoil rights, but the preference given

the land-owner for denouncement or any other rights he may have on the subsoil in case article 27 of the new Constitution is passed or revised by Congress.

Oil land is very expensive in Mexico, the custom being to pay a certain price per hectare(two and one half acres) per year rental and a royalty averaging ten percent. The prices range from two pesos up to one hundred pesos per hectare per year, and when the land is also denounced an additional rental of five pesos per hectare per year is paid to the Mexican Government. However, if article 27 of the new Constitution is finally passed by Congress, the oil operators will only have to pay the rent direct to the government, as the land-owner will have no rights over the subsoil.

THE OIL LEGISLATION.

It is not the purpose of the writer to go into a thorough discussion of the new Mexican oil legislation as it involves a long study not within the scope of this paper. Furthermore the matter of the laws on petroleum still under study by the Mexican Congress, is too difficult to be treated here and has already been the subject of much discussion by many prominent Mexican and American lawyers who have not fully agreed as to the advisability of the change made to the old oil legislat-

ion. Owing therefore to the intricate nature of the subject which involves a study outside of the scope of this paper and to the fact that a thorough discussion of the new oil legislation would rather pertain to a paper on laws than to the present thesis, I will only touch on the new law pointing out the changes that hav been made and why it has raised so much discord between the large foreign interests backed by the American Government, and the Mexican Government.

Article ten, fraction four of the Mexican Mining Code issued in 1884 with respect to oil deposits reads:- "The owner of the surface is the exclusive owner and has not the necessity of denouncing or asking for especial adjudication before the government, having the right to explore and exploit: IV.- All salts existing at the surface; all subterraneous and surface pure and salt waters, oil and gaseous emmanations and also all thermal and medicinal waters".

All the foreign companies when they came to Mexico and started oil explorations obtained the land they now hold direct from the owner either by lease or by direct purchase, according to the Mining Code then in force. However, in the constitution issued by the Constitutional Congress assembled at Aguascaliente in May 1917 this code was changed by declaring as the

property of the nation not only all subsoil metals, but also including all minerals such as salts, oil deposits and other hydrocarbons. According to this new law the subsurface rights held by the oil companies or the landowners are no longer theirs but they become the property of the nation and in order to operate in the oil land held by them they have to denounce it before the government paying a certain amount per hectare per year. The owner of the land is also dispossed of his subsoil rights.

The new legislation has raised very much discord between the oil companies and the Mexican government, the former claiming that the new law known under the name of article 27 is of retroactive action, while the latter holds that it is not a retroactive law because there existed a law previous to the mining code of 1884 which declared subsoil deposits of any nature the property of the nation. The government also claims that the nationalization of the petroleum deposits is legal because it is a public utility.

Although up to the present time Article 27 has not been enforced, the present Mexican Government has not caused its derogation but is only pending a close study of the by-laws by Congress before being put in force. In the mean time the President has issued

a number of decrees regulating the petroleum industry and assessing a tax on the companies properties. As to the final action of Congress it is not definitely known but it is the general belief that the new law will be applied only to land which was not leased previous to May 1917.

At present, only a tax is assessed on all oil exported, which is based on the gravity of the oil and the market price. The export tax is ten percent ad valorem.

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INDEX.